US006845947B1

(12) United States Patent
Reese, Jr. et al.

(10) Patent No.: US 6,845,947 B1
(45) Date of Patent: Jan. 25, 2005

(54) AIRCRAFT CANOPY JETTISON APPARATUS WITH AIRBAG

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(73) Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, DC (US)

(21) Appl. No.: **10/681,499**

(22) Filed: **Oct. 9, 2003**

(51) **Int. Cl.**[7] **B64C 1/00**

(52) **U.S. Cl.** .... **244/120**; 244/122 A; 244/122 AF; 244/122 AE; 244/122 AG

(58) **Field of Search** .... 244/120, 122 A, 244/122 AF, 122 AG, 122 AE; 89/1.57, 1.6, 1.1

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Assistant Examiner—Lulit Semunegus
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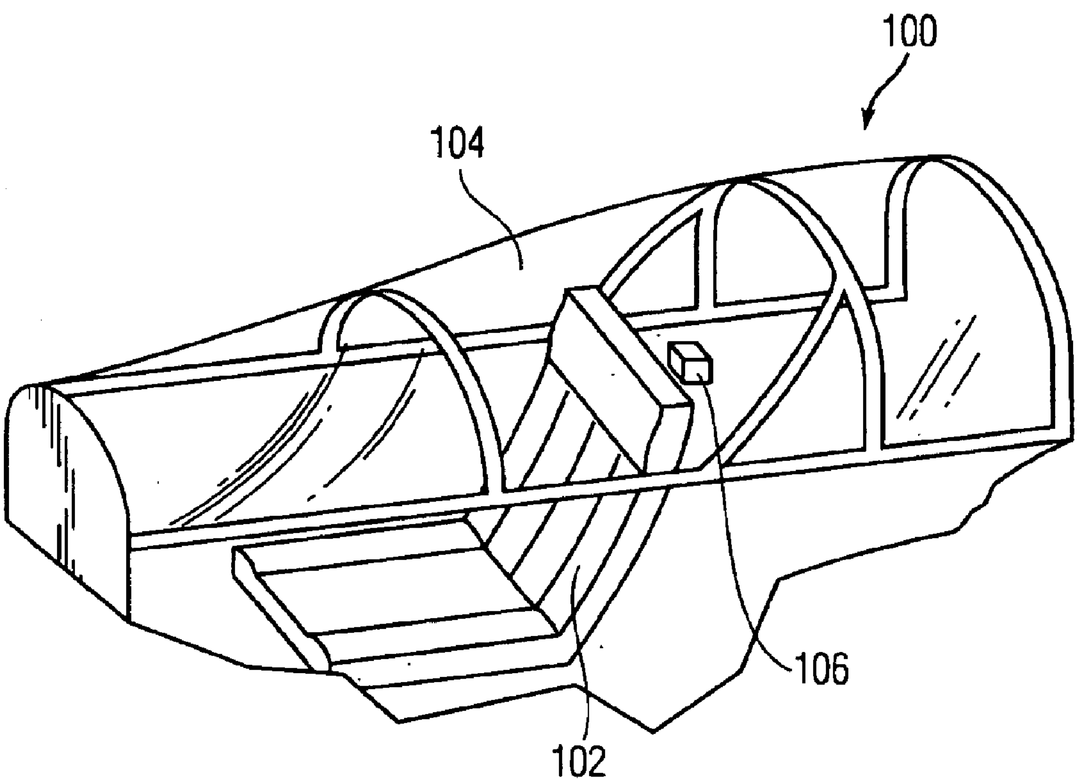
(57) **ABSTRACT**

A method of removing a canopy from a cockpit of an aircraft comprising providing an airbag in the cockpit adjacent the canopy; inflating the airbag; and as the airbag inflates, applying a force to the canopy from the inflating airbag to thereby jettison the canopy.

15 Claims, 8 Drawing Sheets



Eq 1: $\sum M_a = I_a \alpha_1$

Eq 2: $\sum M_a = M_{input} - W_g B$

Eq 3: $M_{input} - W_g B = I_a \alpha_1$

Eq 4: $\alpha_1 = \frac{M_{input} - W_g B}{I_a}$

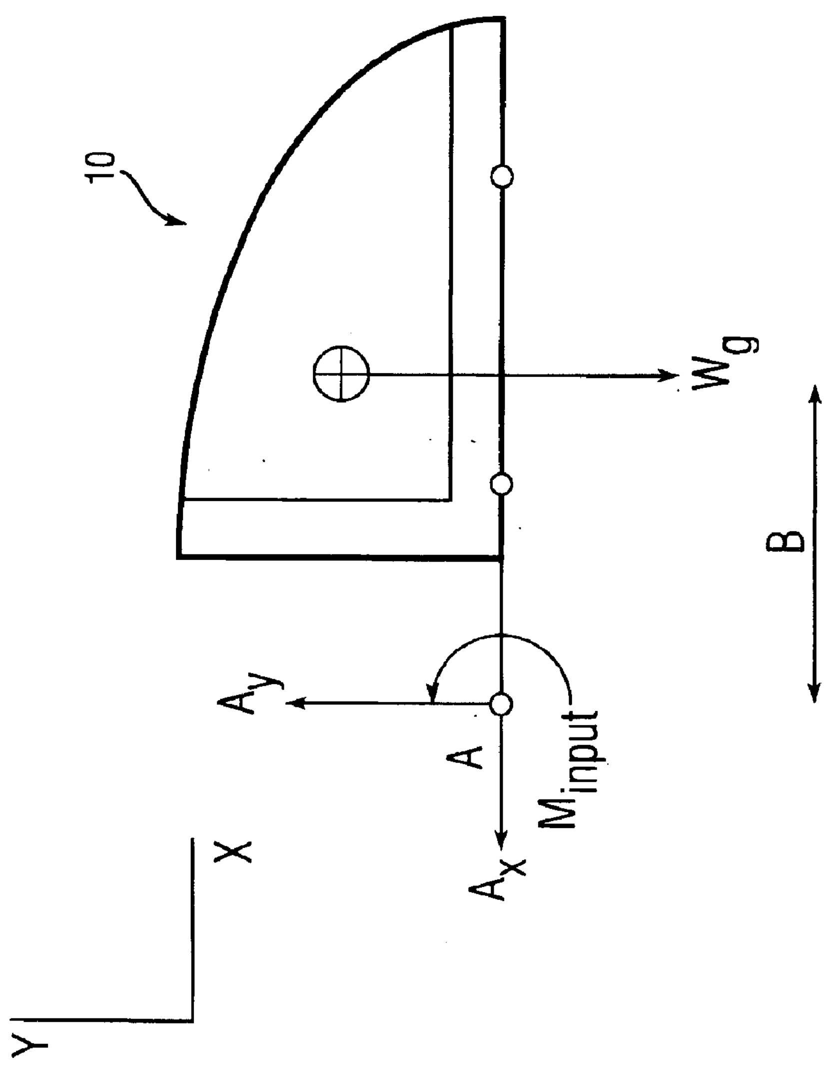
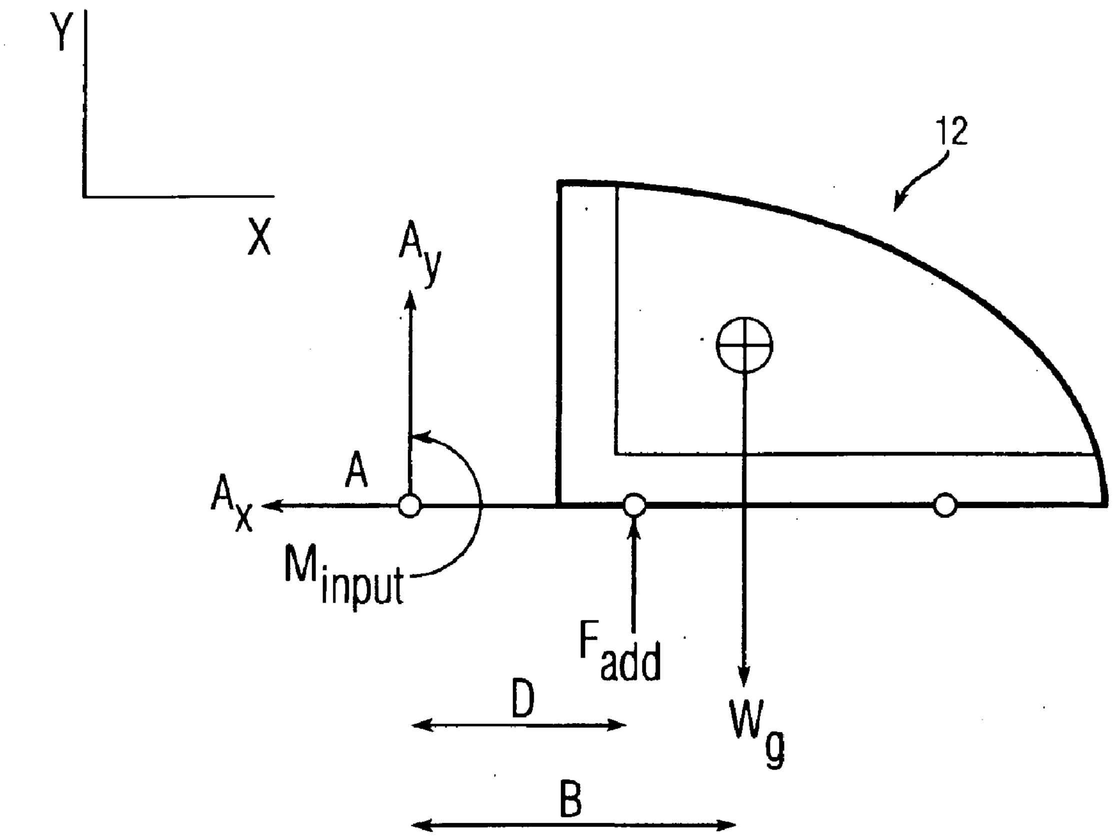


Fig. 1



Eq 5: $\sum M_a = I_a \alpha_2$

Eq 6: $\sum M_a = M_{input} - W_g B + F_{add} D$

Eq 7: $M_{input} - W_g B + F_{add} D = I_a \alpha_2$

Eq 8: $\alpha_2 = \dfrac{M_{input} - W_g B + F_{add} D}{I_a}$

Fig. 2

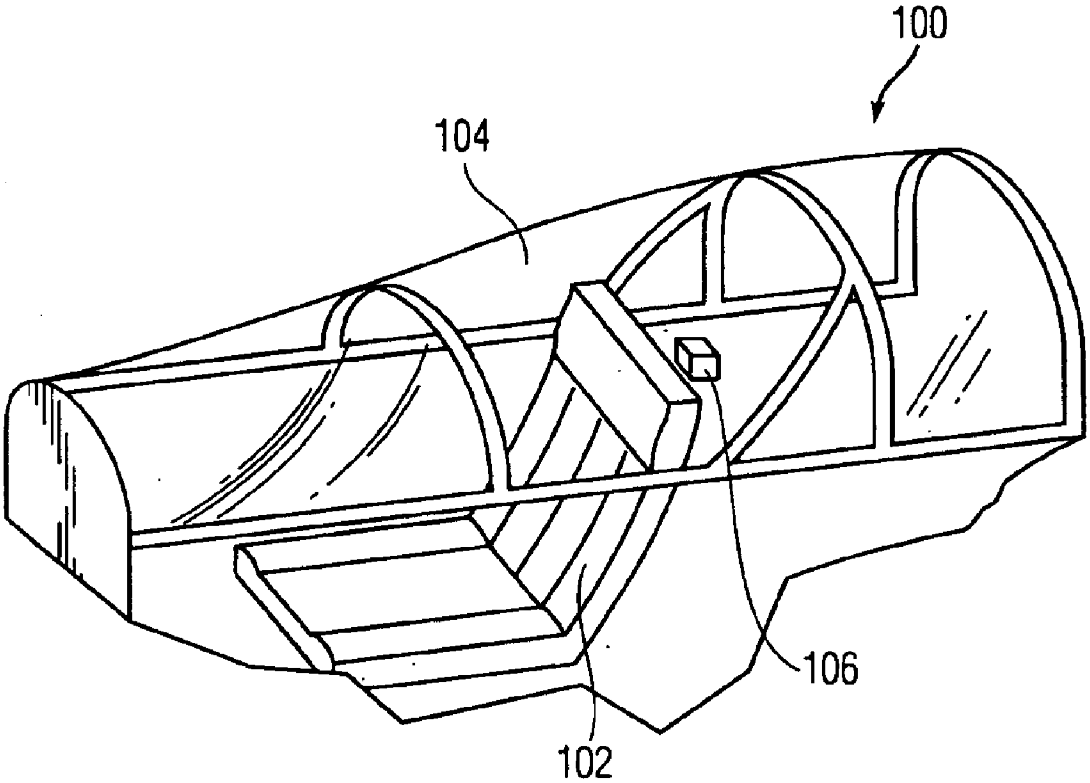
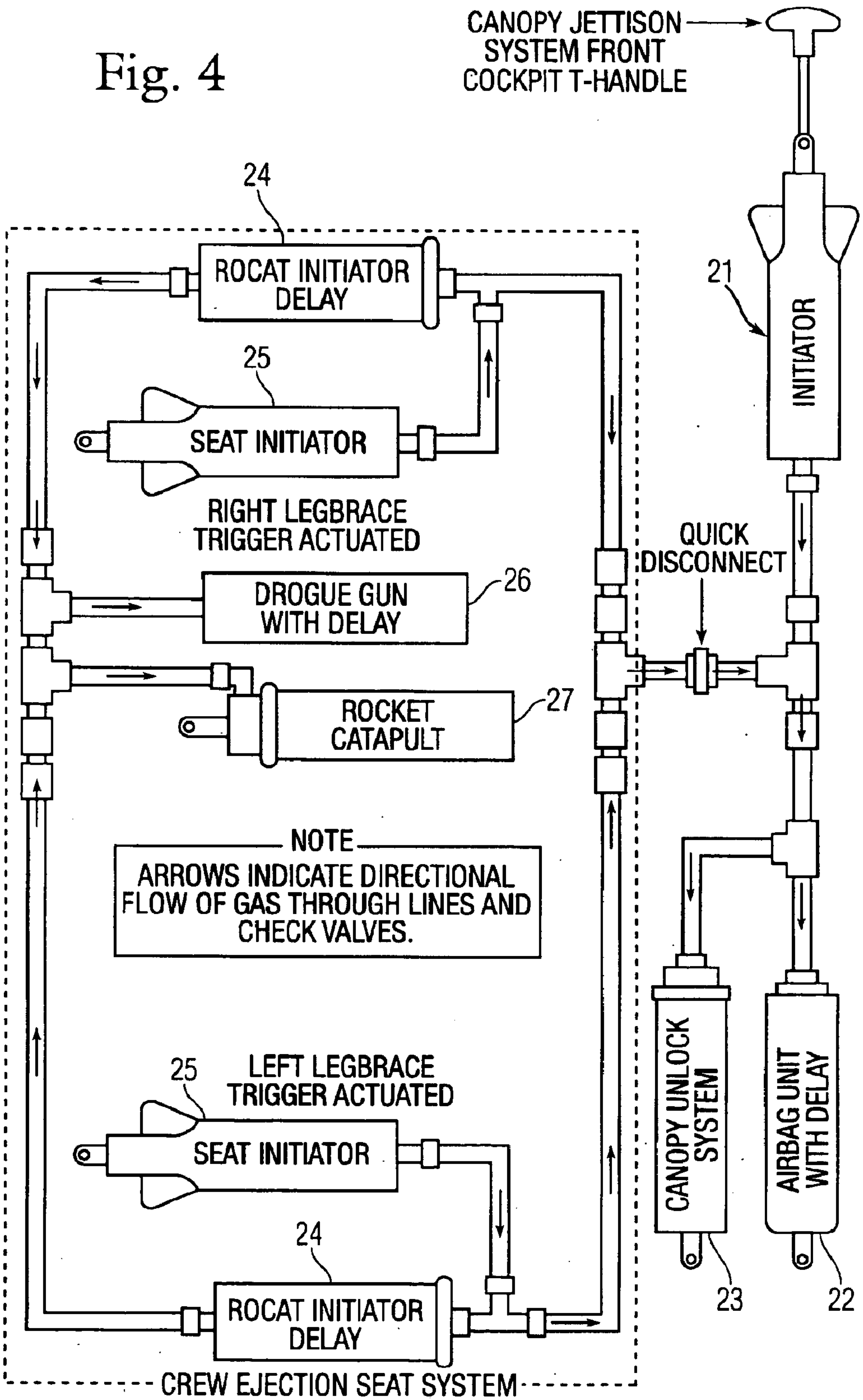


Fig. 3

Fig. 4



FRONT COCKPIT

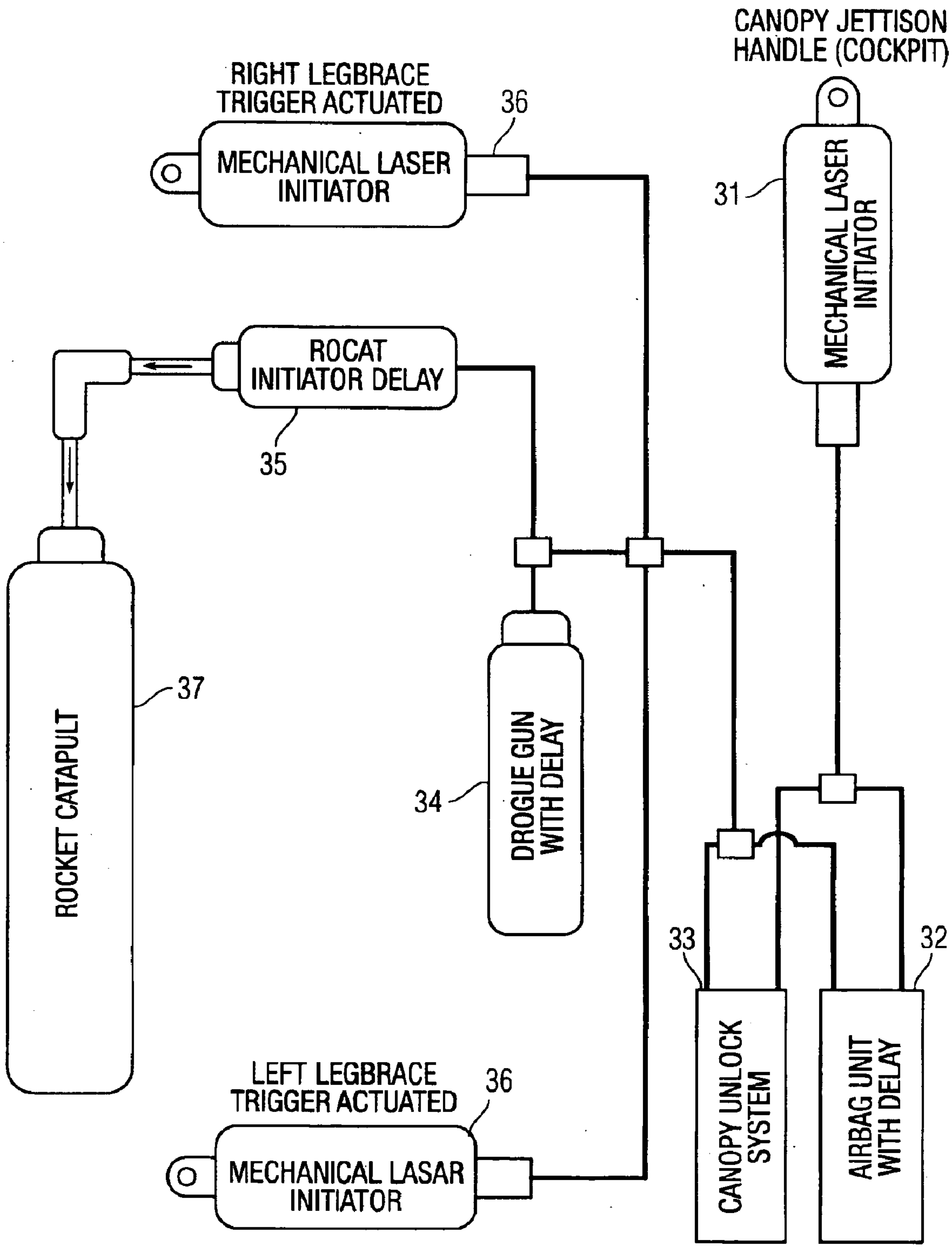

CANOPY JETTISON
HANDLE (COCKPIT)
RIGHT LEGBRACE
TRIGGER ACTUATED
36
MECHANICAL LASER
INITIATOR
31
MECHANICAL LASER
INITIATOR
ROCAT
INITIATOR DELAY
35
37
ROCKET CATAPULT
34
DROGUE GUN
WITH DELAY
33
32
LEFT LEGBRACE
TRIGGER ACTUATED
36
MECHANICAL LASAR
INITIATOR
CANOPY UNLOCK
SYSTEM
AIRBAG UNIT
WITH DELAY

Fig. 5

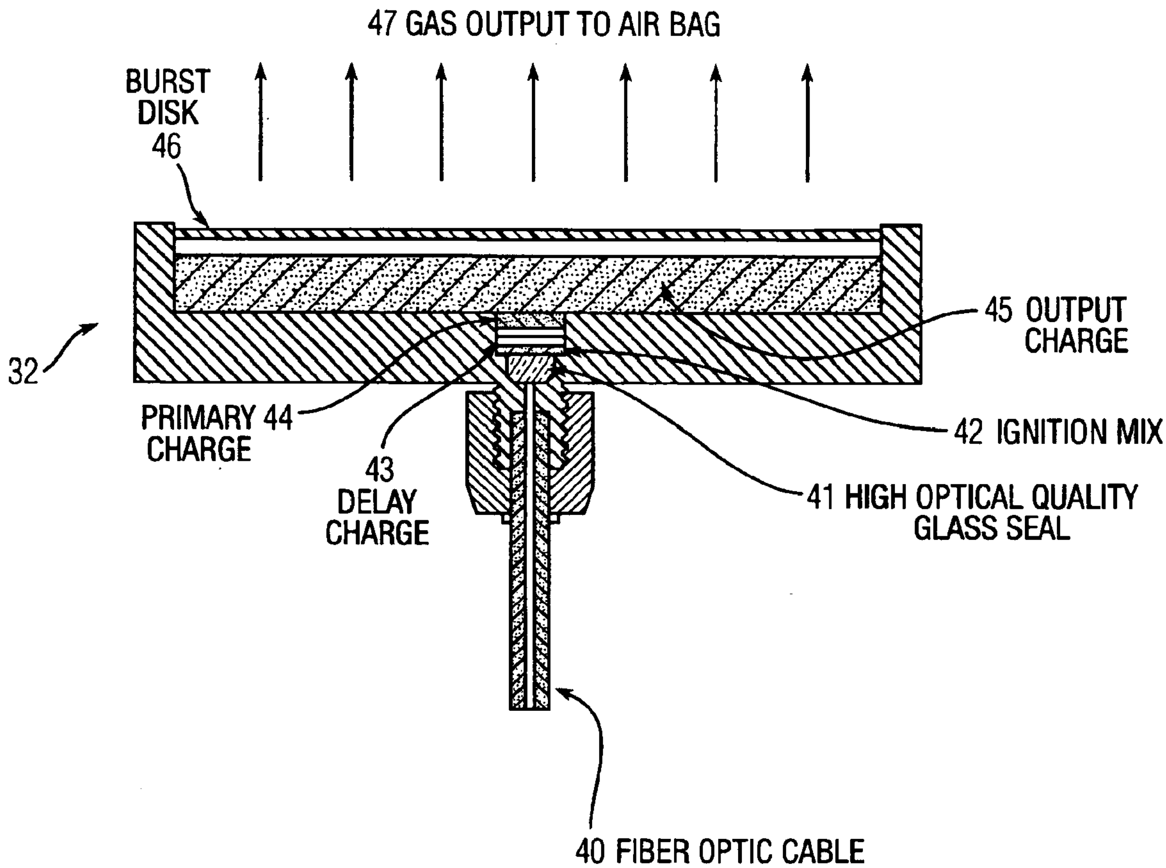

47 GAS OUTPUT TO AIR BAG
BURST DISK 46
32
45 OUTPUT CHARGE
PRIMARY 44 CHARGE
42 IGNITION MIX
43 DELAY CHARGE
41 HIGH OPTICAL QUALITY GLASS SEAL
40 FIBER OPTIC CABLE

Fig. 6

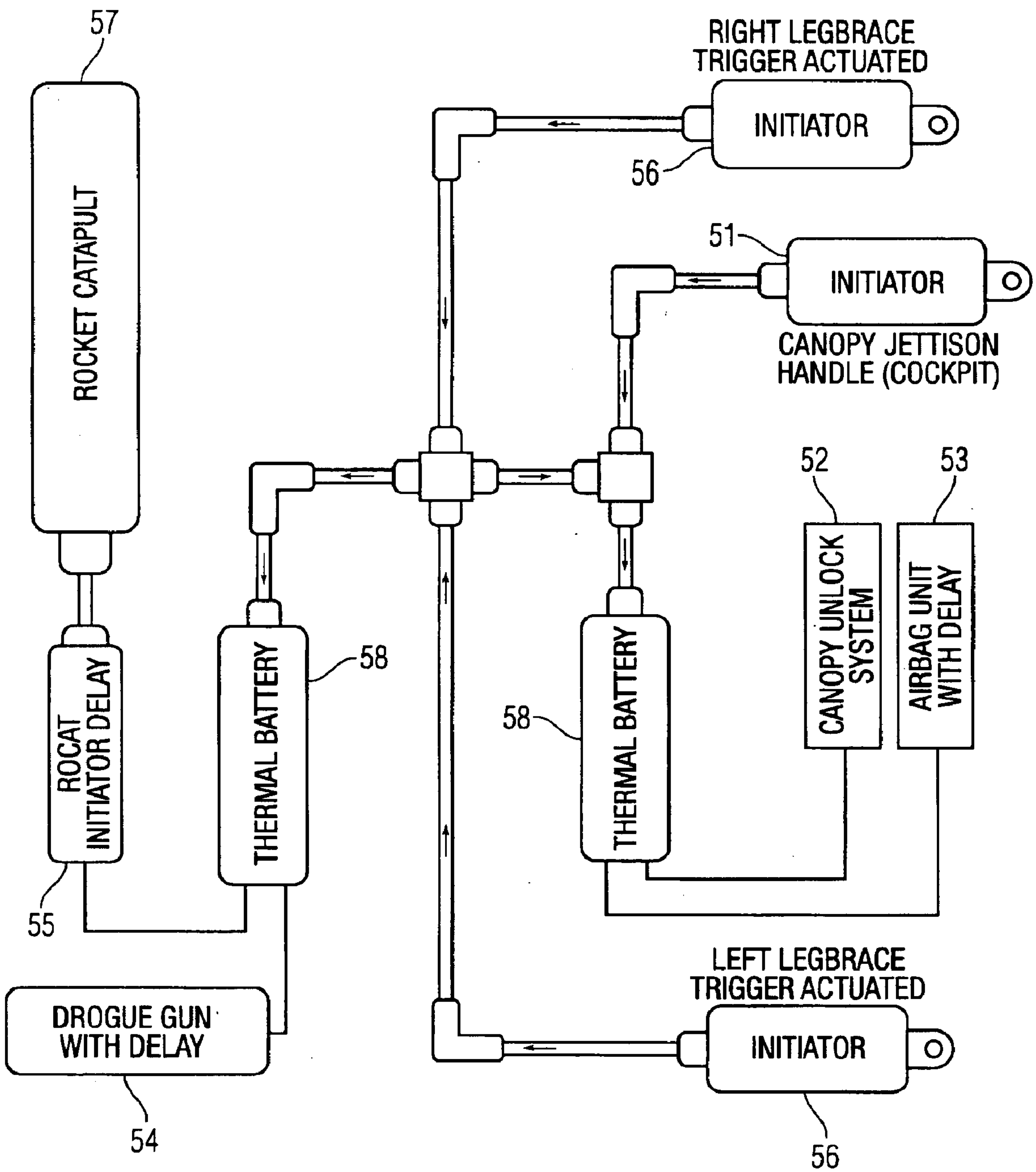

57
ROCKET CATAPULT
RIGHT LEGBRACE
TRIGGER ACTUATED
INITIATOR
56
51
INITIATOR
CANOPY JETTISON
HANDLE (COCKPIT)
52
53
CANOPY UNLOCK
SYSTEM
AIRBAG UNIT
WITH DELAY
ROCAT
INITIATOR DELAY
THERMAL BATTERY
58
58
THERMAL BATTERY
55
DROGUE GUN
WITH DELAY
54
LEFT LEGBRACE
TRIGGER ACTUATED
INITIATOR
56

Fig. 7

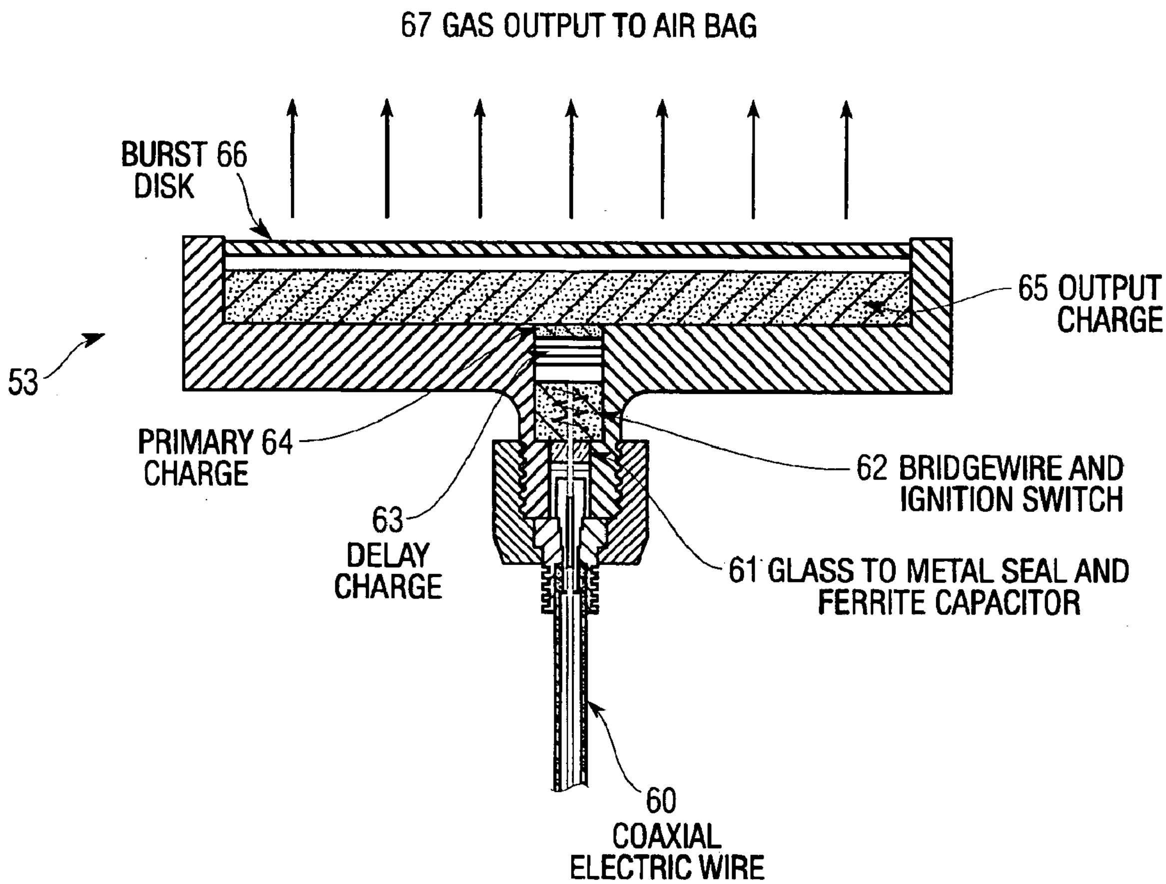

67 GAS OUTPUT TO AIR BAG
BURST 66
DISK
65 OUTPUT
CHARGE
53
PRIMARY 64
CHARGE
62 BRIDGEWIRE AND
IGNITION SWITCH
63
DELAY
CHARGE
61 GLASS TO METAL SEAL AND
FERRITE CAPACITOR
60
COAXIAL
ELECTRIC WIRE

Fig. 8

AIRCRAFT CANOPY JETTISON APPARATUS WITH AIRBAG

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for government purposes without the payment of any royalties therefor.

BACKGROUND OF THE INVENTION

The invention relates in general to aircraft canopy jettison apparatus and in particular to aircraft canopy jettison apparatus that include an airbag.

There are three known ways to jettison an aircraft canopy during an emergency egress situation. The three ways are rocket motors, canopy thruster(s), and canopy fragilization. All three have advantages and disadvantages that dictate the effectiveness of a pilot's safe egress from an aircraft.

Many older military aircraft still in service use a canopy thruster in combination with mechanical linkages to remove the canopy from an aircraft. Some of the limitations of using a canopy thruster have been seen over the past few years. Timing is a key factor to ensuring the successful egress of aircrew from an aircraft. The use of mechanical linkages to assist in the removal has a strong dependence on the resilience of these linkages. The failure of one part in the series of linkages can cause the canopy to remain attached to the aircraft or cause a delay in the timing of events and possible injury to the aircrew.

Canopy jettison by way of rocket motors is currently used in military aircraft. One problem with using rocket motors is the extreme amounts of noise generated, which can damage an aircrew's hearing. Another problem with using rocket motors is the proximity of the rocket plume to the aircrew, which can cause serious injury to the aircrew.

Canopy fragilization has recently been incorporated into new aircraft designs over the past decade as a means for canopy removal during an emergency egress situation. One disadvantage of canopy fragilization is the use of explosives, in close proximity to the aircrew, to blow the transparent glass out of the canopy's metal frame. One concern when using this method is the likelihood of fragments hitting the aircrew. Another disadvantage is the noise that may be encountered due to the proximity of the aircrew to the explosive charge. One key factor to a successful disintegration of the transparent glass is in the determination of how much explosive material is needed to fragment the transparent part of the canopy into small pieces.

SUMMARY OF THE INVENTION

The present invention uses airbag technology to perform and/or assist in the work function of canopy removal for an aircraft during an emergency egress. In general, the airbag system comprises an inflatable airbag and a cartridge actuated device (CAD). The operation of the airbag starts by the initiation of the CAD. The CAD outputs gas that inflates the airbag. As the airbag begins to inflate, it forces the canopy open. Given the proper placement of the airbag, the distributed force applied to the canopy causes the canopy to be jettisoned from the aircraft. The airbag may be fixed to the airframe, canopy or ejection seat. The adaptability of an airbag system allows for an upgrade of existing aircraft's egress system; thereby serving to improve or solve escape path clearance related issues.

The invention will be better understood, and further objects, features, and advantages thereof will become more

apparent from the following description of the preferred embodiments, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are not necessarily to scale, like or corresponding parts are denoted by like or corresponding reference numerals.

FIG. **1** is a force diagram of a canopy without an airbag.

FIG. **2** is a force diagram of a canopy with an airbag.

FIG. **3** is a perspective view of a cockpit portion of an aircraft with the fuselage skin removed for clarity.

FIG. **4** is a schematic diagram of an apparatus including a gas initiated airbag for canopy jettison.

FIG. **5** is a schematic diagram of an apparatus including a laser initiated airbag for canopy jettison.

FIG. **6** is a schematic side view of a portion of a laser initiated airbag.

FIG. **7** is a schematic diagram of an apparatus including an electrically initiated airbag for canopy jettison.

FIG. **8** is a schematic side view of a portion of an electrically initiated airbag.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is a force diagram of a canopy **10** without an airbag and FIG. **2** is a force diagram of a canopy **12** with an airbag. FIGS. **1** and **2** represent the difference between using an airbag (FIG. **2**) as an additional force input to an existing canopy jettison system and one without the airbag (FIG. **1**). The following analysis assumes that there is no air resistance and at the instant the canopy begins movement that $A_x=0$ and the angular velocity (w)=0. Equations 1 and 5 in FIGS. **1** and **2**, respectively, are the equations for angular motion about a fixed point. Equations 1–4 relate to FIG. **1** and equations 5–8 relate to FIG. **2**. The equations 1–8 are shown on the Figs. for clarity. The variables of the equations are:

A: the axis of rotation point for the canopy.

A_x: the reaction force in the positive x-direction. Units are (lbf) or (N)

A_y: the reaction force in the positive y-direction. Units are (lbf) or (N)

Minput: the initial momentum that is given to the canopy from a pre-existing canopy jettison system. Units are (ft–lbf) or (N–m).

Fadd: the force that is generated from the airbag. Units are (lbf) or (N)

D: the distance of Fadd relative to the axis of rotation located at point A. Units are (ft) or (m)

Wg: the weight due to gravity of the canopy, which is located at the canopy's center of gravity (c.g). Units are (lbf) or (N)

B: the distance of Wg relative to the axis of rotation located at point A. Units are (ft) or (m)

EM_a: the sum of the moments about point A. Units are (ft–lbf) or (N–m)

α: the angular acceleration. Units are radians per second squared.

I: the mass moment of inertia. Units are (slug–ft^2) or (kg–m^2).

In FIG. **2**, Fadd, which is located by the distance D, can be positioned anywhere horizontally on the canopy **12** to get an increase in acceleration. This allows for a faster canopy removal time. A comparison of equations 4 and 8 from FIGS. **1** and **2**, respectively, shows that α_2 is greater than α_1.

Thus, the angular acceleration of the canopy **12** with the airbag is faster than the angular acceleration of the canopy **10** without the airbag. The total momentum that is being applied to the canopy **12** is greater than that for canopy **10**. The increased momentum causes an increase in the overall distance relative to the starting position.

The size and shape of the airbag is dependent upon the space limitations inside the cockpit. In general, the amount of force required to jettison a canopy of a given shape, size, and weight determines the size and shape of the airbag. The position of the airbag in the cockpit depends on the best mounting surface available on the inside of the cockpit. For example, the airbag may be fixed to the airframe, canopy or ejection seat. FIG. **3** is a perspective view of a cockpit portion of an aircraft **100** with the fuselage skin removed for clarity. In FIG. **3**, the cockpit portion includes a pilot seat **102**, a transparent canopy **104** and an airbag **106**. The airbag **106** is mounted on a bulkhead behind the pilot seat **102**.

FIG. **4** is a schematic diagram of an apparatus including a gas initiated airbag for canopy jettison. Initiator **21**, for example, a CAD, initiates the canopy jettison and ejection seat sequence. (A CAD is a small, self-contained energy source that is used to perform mechanical work.) An air bag unit **22** with a built in time delay is fluidly connected to the initiator **21**. A canopy unlock system **23** is also fluidly connected to the initiator **21**. The canopy unlock system **23** unlocks the canopy thereby allowing the canopy to move freely. Other components of the apparatus include two ejection seat initiators **25** that can function the same as initiator **21**, that is, the ejection seat initiators **25** can initiate both the canopy jettison and ejection seat sequence. Two rocket catapult (ROCAT) delay units **24** ensure the proper firing of the drogue gun and rocket catapult. The drogue gun **26** is used to stabilize the seat. The rocket catapult **27** provides the main thrust that launches the pilot and seat out of the cockpit.

Initiation of the airbag **22** begins with activation of one of the initiator **21** or an ejection seat initiator **25**. The initiator **21** or ejection seat initiator **25** releases gas into the fluid lines that interconnect the system components. The input signal of gas strikes a firing pin in the air bag unit **22**. The firing pin strikes the CAD of the air bag, causing the CAD to release exhaust gases into the air bag. As the air bag fills up and expands, it applies a force to the canopy.

FIG. **5** is a schematic diagram of an apparatus including a laser initiated airbag **32** for canopy jettison. A mechanical laser initiator **31** is located in the cockpit and sends a pulse to initiate the canopy jettison only. Laser initiated airbag **32** includes a CAD and a built in time delay. Canopy unlock system **33** includes a laser initiated CAD and the mechanism used to unlock the canopy from the airframe. Drogue gun **34** includes a laser initiated CAD with a built in time delay. A laser initiated rocket catapult (ROCAT) time delay **35** supplies a hot gas output to rocket catapult **37**. Dual mechanical laser initiators **36**, disposed on the ejection seat, send a laser pulse to initiate canopy removal and the seat ejection sequence (rocket catapult and drogue gun). The rocket catapult **37** provides the main thrust that launches the pilot and seat out of the cockpit.

FIG. **6** is a side view of a portion of a laser initiated airbag **32**. A fiber optic cable **40** carries a laser pulse signal from the cockpit mechanical laser initiator **31** or one of the dual mechanical laser initiators **36**, disposed on the ejection seat, to the airbag **32**. The laser signal passes through a high optical quality glass seal **41** to an ignition charge **42**. The laser signal activates the ignition charge **42**, which activates the delay charge **43**. After the delay, the delay charge **43** activates the primary charge **44**, which activates the output charge **45**. The output charge **45** produces gases that break the burst disk **46** and then fill and expand the airbag **32**.

FIG. **7** is a schematic diagram of an apparatus including an electrically initiated airbag **53** for canopy jettison. A cockpit initiator **51** sends a hot gas signal to initiate canopy jettison only. Electrically initiated canopy unlock system **52** includes a CAD and the mechanism used to unlock the canopy from the airframe. Electrically initiated airbag **53** includes a CAD and a time delay. Electrically initiated drogue gun **54** includes a CAD with a built in time delay. Electrically initiated rocket catapult (ROCAT) time delay **55** outputs hot gas to rocket catapult **57**. Dual initiators **56** on the ejection seat send a hot gas signal to initiate both canopy removal and the ejection sequence (rocket catapult and drogue gun). Rocket catapult **57** provides the main thrust that launches the pilot and seat out of the cockpit. Thermal battery **58** converts chemical energy to electrical energy for signal transfer and initiation of CADs.

FIG. **8** is a side view of a portion of an electrically initiated airbag **53**. A coaxial electrical wire **60** carries an electrical signal from the thermal battery **58** to the airbag **53**. The electrical signal passes through a glass to metal seal and a ferrite capacitor **61** installed for HERO (Hazards of Electromagnetic Radiation to Ordnance) purposes. The electrical signal resistively heats the bridgewire thereby igniting the ignition charge **62**, which in turn ignites the delay charge **63**. After the delay, the delay charge **63** activates the primary charge **64** which activates the output charge **65**. The output charge **65** produces gases that break the burst disk **66** and then fill and expand the airbag **53**.

While the invention has been described with reference to certain preferred embodiments, numerous changes, alterations and modifications to the described embodiments are possible without departing from the spirit and scope of the invention as defined in the appended claims, and equivalents thereof.

What is claimed is:

1. A method of removing a canopy from a cockpit of an aircraft, comprising:

providing an airbag in the cockpit adjacent the canopy;

inflating the airbag; and

as the airbag inflates, applying a force to the canopy from the inflating airbag to thereby jettison the canopy.

2. The method of claim **1** further comprising initiating the airbag prior to inflating the airbag.

3. The method of claim **2** wherein the initiating step includes initiating the airbag with gas.

4. The method of claim **2** wherein the initiating step includes initiating the airbag with a light signal.

5. The method of claim **2** wherein the initiating step includes initiating the airbag with an electrical signal.

6. The method of claim **1** wherein the airbag is mounted to a cockpit seat.

7. The method of claim **1** wherein the airbag is mounted to the canopy.

8. The method of claim **1** wherein the airbag is mounted to an airframe of the aircraft.

9. An apparatus, comprising:

an aircraft having a cockpit and a canopy covering the cockpit;

an airbag mounted in the cockpit adjacent the canopy; and

an initiator connected to the airbag for initiating the airbag to jettison the canopy.

10. The apparatus of claim **9** wherein the initiator is a gas initiator.

11. The apparatus of claim 9 wherein the initiator is a laser initiator.

12. The apparatus of claim 9 wherein the initiator is an electrical initiator.

13. The apparatus of claim 9 further comprising a cockpit seat in the cockpit and wherein the airbag is mounted to the cockpit seat.

14. The apparatus of claim 9 wherein the airbag is mounted to the canopy.

15. The apparatus of claim 9 wherein the aircraft comprises an airframe and wherein the airbag is mounted to the airframe.

* * * * *